

GENERIC CLUSTER CORE COURSE I
CELL AND MOLECULAR BIOLOGY
Course Code: 24ULS401

Contact Hours/ Week: 04

Credit: 04

Internal Marks: 40

External Marks: 60

Course Outcomes:

- CO1 Understand the basic structure and function of the cells.
- CO2 Understand the significance of Mitosis and Meiosis Cell division.
- CO3 Interpretate the Structure and functions of Nucleic acids
- CO4 Gain Knowledge on the central dogma of cells.
- CO5 Acquire knowledge on gene regulation and its Significance.

SYLLABUS

Unit:1-The Cell:

Historical background, Cell theory, Cell size and Structure, Comparative account of prokaryotic and eukaryotic cell. Structures and Functions of Cell Organelles: Nucleus, Ribosomes, Nucleoplasm, Mitochondria and Chloroplast, Types of plastids, Golgi complex, Endoplasmic Reticulum, Lysosomes, Peroxisomes

Unit:2- Chromosomes:

History, types and functions of chromosomes. Giant chromosomes, Polytene chromosome and Lampbrush chromosome. Chromosomal Aberrations. Cell cycle - Cell Division: Mitosis (cell cycle stages, cytokinesis) Meiosis (reproductive cycle stages, synaptonemal complex, recombination nodules). Comparison between Mitosis and Meiosis and their significance.

Unit:3- Structure and Type of DNA and RNA:

Structure, functions and type of DNA, Watson And Crick's structural model of DNA, chemical composition of DNA, replication of DNA. DNA as genetic material. Structure of RNA (primary, secondary and tertiary structure) and types of RNA (transfer RNA, messenger RNA, ribosomal RNA). Function and importance of RNA.

Unit: 4- Central Dogma

Transcription and Translation in prokaryotes and Eukaryotes. DNA Repair mechanism. Genetic Code: Properties of genetic code, codon and anti codon, The Wobble Hypothesis, Mutation and the triplet code.

Unit: 5- Gene regulation

Operon hypothesis: regulator gene, promoter gene, operator gene, structural gene, repressor gene, corepressor gene and inducer gene. Regulation at transcription, regulation by gene arrangement and reversible phosphorylation, types of control mechanisms, regulation of gene activity in eukaryotes.

Text Book:

1. Cell Biology, Genetics, Molecular Biology, Evolution & Ecology- P.S.Verma, V.K. Agarwal

Reference Books:

1. Molecular biology-P.C. Turner, A.G. McLennan, A.D. Bates & M.R.H. white.
2. Principles of Genetics- D.Peter Snustad, Michael J. Simmons.
3. Hand Book of Life Science- Sunil Patel, Rukum. S. Tomar, Harsukin Gazera, B.A.
4. Golakiya & Manoj Parakhia.
5. Watson, J. D. et al. (2017) Molecular Biology of Gene. 7th edition. Pearson.
6. Freifelder D (2012). Molecular Biology, 5th edition. Narosa Publishing House, India

GENERIC CLUSTER LAB COURSE - I
PRACTICAL IN CELL AND MOLECULAR BIOLOGY

Course Code: 24UBT451

Contact Hours/ Week: 04

Credit: 02

Internal Marks: 40

External Marks: 60

Course Outcomes:

- CO1 Understand of laboratory safety rules and protocols.
- CO2 Identify and describe the structures of various cell types using microscopy techniques
- CO3 Analyze the Mitosis and Meiosis Cell Division
- CO4 Demonstrate Nucleic acid Isolation and Estimation
- CO5 Familiarize DNA transformation techniques

SYLLABUS

1. Preparation of different stock solutions used in molecular biology (Solutions used in electrophoresis, DNA isolation, RNA isolation and Protein isolation)
2. Microscope
3. Micrometry
4. Cell division - Mitotic stages - Preparation of Onion Root Tip
5. Meiotic study in flower buds and cockroach or grasshopper
6. Giant chromosome studies in Chironomous larvae.
7. Cell counting and cell viability 8.Isolation of DNA from bacteria
8. Isolation of DNA from plants
9. Isolation of DNA from animal tissue
- 10.Quantification of DNA and RNA through spectrophotometer
- 11.Separation of different sized DNA fragments on agarose gel
- 12.Transformation of Bacteria- Chemical Method.

Text Books:

1. Dr. David A Thompson, 2009. Cell and Molecular Biology Lab Manual, 1st Edition, CreateSpace publishers.
2. Quincy Quick. 2009. Cell and Molecular Biology Laboratory Manual. Quincy Quick Publishing,
3. Julio E. Celis. 2006. Cell biology: a laboratory handbook, Elsevier Academic,

ALLIED COURSE I
ANIMAL DIVERSITY
Course Code: 24UZO301

Contact Hours/ Week:03

Credits:03

Internal Mark: 25

External Mark: 75

Course Outcomes:

- CO-1 Understand the basic concepts of lower animals and observe the structure and functions.
- CO-2 Understand and illustrate the systemic and functional morphology of various group of invertebrates.
- CO-3 Understand the structural and functional organisation of some invertebrates and chordates
- CO-4 Understand the adaptations and habits of animals to their habitat
- CO-5 Analyse the development stages of Evolution.

SYLLABUS

UNIT – I

Diversity of Invertebrates–I: Principles of taxonomy. Criteria for classification –Symmetry and Coelom –Binomial nomenclature. General Characteristics and Economical Importance of Protozoa, Porifera, Coelenterata, Helminthes. Detailed Study of Protozoa and Helminths.

UNIT – II

Diversity of Invertebrates–II general Characteristics, Economical Importance and Detailed Study of of Annelida – Earthworm and Cockroach, Arthropoda - Prawn, Mollusca - Fresh water mussel, Echinodermata - Sea star, Mouth parts of insects.

UNIT – III

Diversity of Chordates–I Chordata - General charter and Classification, Type study includes Morphology, digestive system, respiratory system, circulatory system and urinogenital system of Chordate, Shark, and Frog.

UNIT – IV

Diversity of Chordates–II General charter and Classification, Type study includes Morphology, digestive system, respiratory system, circulatory system and urinogenital system of Chordate, Calotes, Pigeon and Rat General topic: Migration in fishes. Poisonous and non-poisonous snakes in India.

UNIT – V:

Developmental Biology & Evolution: General account on gametogenesis- fertilization and developmental stages. Importance of Paelaeontology - Origin of life - Darwinism- Modern synthetic theory.

Text Books

1. Berril, N.J. 1971. Developmental Biology, McGraw Hill, New York.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science.
3. Barnes, R.D. (1982). Invertebrate Zoology, V Edition. Holt Saunders International Edition.
4. Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson
5. Boradale, L.A. and Potts, E.A. (1961). Invertebrates: A Manual for the use of Students. Asia Publishing Home.

6. Lal, S.S. 2005. A text Book of Practical Zoology: Invertebrate, Rastogi, Meerut

REFERENCES:

1. Ayyar, E.K. and T.N. Ananthakrishnan. 1992. Manual of Zoology. Vol I & II, S.Viswanathan (printers and publishers) Pvt. Ltd., Madras, 891 p.
2. Kotpal series, 1998 - 1992. Rastogi Publications, Meerut.
3. Jordan E.L. and P.S. Verma. 1993. Invertebrate Zoology 12th edition, S. Chand & Co.,Ltd., New Delhi.
4. Jordan, E.L., and P.S. Verma. 1995. Chordate Zoology and Elements of Animal Physiology, S. Chand & Co., Ltd., New Delhi.

ALLIED LABORATORY I
ANIMAL DIVERSITY AND OCCUPATIONAL ZOOLOGY

Course code: 24UZO351

Contact Hours/ Week:04

Credits:02

Internal Mark: 40

External Mark: 60

Course Outcomes:

- CO1 Understand the basic concepts of lower animals and observe the structure and functions.
- CO2 Understand and illustrate the systemic and functional morphology of various group of invertebrates.
- CO3 Understand the structural and functional organisation of some chordates
- CO4 Understand the developmental stages and Evolution
- CO5 Analyse the opportunities available for conservation and research development.

SYLLABUS

DISSECTION / DEMO / CD / VIRTUAL:

1. Earthworm - Digestive and Nervous system.
2. Cockroach- Digestive and Nervous system.
3. Fish - Digestive and Nervous system.
4. Chick embryo study

MOUNTING:

1. Mouth parts – honeybee, cockroach and mosquito (slide).
2. Earthworm – body setae and penial setae.
3. Fish – cycloid scale, ctenoid scale and placoid scale.
4. Pila Radula (Slide)

SPOTTERS:

Invertebrata – Protozoa, Porifera, coelenterata, Helminthes, Earthworm, Prawn, Fresh water mussel sea star, Chordata - Shark, Frog, Calotes, Pigeon, Rat, Cobra.

ECONOMIC IMPORTANCE SPECIES:

Honey, Bee wax - Apiculture

Vermicompost- Vermiculture

Cocoons, silk thread - Sericulture

Catla, Rohu, Mrigal, fresh water prawn (*Macrobrachium rosenbergii*), marine shrimp – (*Penaeus monodon* / *Litopenaeus vannamei*) - Aquaculture

REFERENCES:

1. Verma, P. S. (2013). A Manual of Practical Zoology of Invertebrates. S. Chand of company Ltd, New Delhi.
2. Ekambaranatha Ayyar and Ananthakrishnan, T. N. (2009). Manual of Zoology Vol – II. S. Viswanathan Pvt. Ltd. Chennai.
3. Poddar, T., Mukhopadhyay and Das, S. K. (2003). An Advanced Laboratory Manual of Zoology. Rajiv Beri for MacMillan Indian limited, Delhi.

**DISCIPLINE CENTRIC CORE I
MICROBIOLOGY AND PLANT DIVERSITY I**

Course Code: 24UBO501

Contact Hours/ Week:05

Credits:04

Internal Mark: 25

External Mark: 75

Course Outcome:

- CO-1 Understand and analyze the diversity and characteristics of microorganisms
- CO-2 Acquire knowledge on microbial reproduction and genetic mechanisms
- CO-3 Classify and analyze key microbial groups
- CO-4 Assess the economic and environmental importance of microorganisms
- CO-5 Investigate ecological relationships and applications

SYLLABUS

UNIT I: Microbes

Introduction Microbes - Bacteria – Discovery, General characteristics and cell structure; Reproduction - vegetative, asexual and recombination (conjugation, transformation and transduction, Isolation of bacteria from various sources (Soil, water and Food) and slide preparation, Economic importance.

UNIT II: Virus

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance

UNIT III: Algae

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae (Fritsch classification); Morphology, Reproduction and life-cycles of the following: Nostoc, Chlamydomonas, Oedogonium, Vaucheria, Fucus, Polysiphonia. Isolation of algae from various sources (BGA, Green, Unicellular) and slide preparation, Economic importance of algae

UNIT IV: Fungi

Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition, nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, structure, reproduction and life cycle of Rhizopus (Zygomycota), Alternaria (Ascomycota), Penicillium, Puccinia, Agaricus (Basidiomycota), Isolation of fungi from various sources, and slide preparation, Economic importance of fungi.

UNIT V: Lichen

Lichen: Classification (Hale, 1969). Habitat, nature of association, Structure, Nature of Mycobionts and Phycobionts, study of growth forms of lichens (crustose, foliose), types, distribution, thallus organization, reproduction and ecological significance of lichens with special reference to Usnea. Isolation of Lichens from various sources and slide preparation, Economic importance of Lichen.

Text Books:

1. S.N. Pandey, S.P. Misra, P.S. Trivedi, A Textbook of Botany Volume - II, 13th Edition, Vikas Publications, 2016.

Reference Books:

1. Tortora, G.J., Funke, B.R., & Case, C.L. Microbiology: An Introduction, 14th Edition, Pearson, 2022.
2. Skrabanek, R.J., & Musk, A.W. Principles and Applications of Virology, 4th Edition, Elsevier, 2023.
3. Barsanti, L., & Gualtieri, P. Algae: Anatomy, Biochemistry, and Biotechnology, 4th Edition, CRC Press, 2021.
4. Alexopoulos, C.J., Mims, C.W., & Blackwell, M. Introductory Mycology, 5th Edition, John Wiley & Sons, 2021.
5. Nash, T.H. III, Rendell, A., & Peveler, W.J. Lichen Biology, 3rd Edition, Cambridge University Press, 2022.
6. Biswas, S.B., Amita Biswas, An Introduction to viruses, Vikas Publications

**DISCIPLINE CENTRIC CORE LABORATORY I
MICROBIOLOGY AND PLANT DIVERSITY I LAB**

Course Code: 24UBO551

Contact Hours/ Week:04

Credits:02

Internal Mark : 40

External Mark:60

Course Outcome:

- CO1 Identify microbes, fungi and lichens using key identifying characters.
- CO2 Develop practical skills for culturing and cultivation of fungi.
- CO3 Observation of specimens and slides
- CO4 Analyze the characteristics of microbes and fungi
- CO5 Discuss microorganism control and their right use

SYLLABUS

1. Tools and equipment used in microbiology: Spirit lamp, Inoculation loop, Hot air oven, Autoclave, Laminar air flow chamber, Incubator.
2. Media preparation, Serial techniques and pure culture techniques. Types of Bacteria from temporary / permanent slides / photographs; Charts, Binary fission, conjugation. Simple and differential staining.
3. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
4. Gram staining
5. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
6. Study of vegetative and reproductive structures of Nostoc, Chlamydomonas (Electron micrographs), *Oedogonium*, *Vaucheria*, *Fucus* and *Polysiphonia* through temporary preparations and permanent slides. (*Fucus* - Specimen and permanent slides)
7. *Rhizopus* and *Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
8. *Alternaria*: Specimens/photographs and tease mounts.
9. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on Wheat and permanent slides of both the hosts.
10. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*
11. *Lichens*: Forms of lichens (crustose, foliose and fruticose)
12. *Lichens*: *Parmelia* *Usnea*

Additional (For DBT Curriculum Revision)

1. Isolation of Bacteria from various sources (Soil, Water, Food)
2. Isolation of Fungi from various sources (Actinomycetes)
3. Microscopic Examination of Fungal Morphology Using Lactophenol Cotton Blue Staining Technique

REFERENCES:

1. Dr. R.C. Dubey Dr. D. K. Maheshwari, Practical Microbiology
2. Biswas C. and Johri B. M. (1997). Gymnosperms. Narosa Publishers, New Delhi.
3. R. Ananthanarayan, J.C. Panicker (2022). Text Book of Microbiology

ALLIED II
OCCUPATIONAL ZOOLOGY
Course Code: 24UZO302

Contact Hours/ Week:03

Credits:03

Internal Mark: 25

External Mark: 75

Course Outcome:

CO-1 Understand the biology, rearing techniques, and economic significance of silkworms for sustainable silk production.

CO-2 Gain knowledge of honeybee biology, beekeeping practices, and the importance of bees in pollination and ecosystem services.

CO-3 Learn vermicomposting techniques, the role of earthworms in organic farming, and their contribution to waste management.

CO-4 Acquire skills in fish and shellfish farming, disease management, and sustainable practices for food security.

CO-5 Develop strategies to integrate sericulture, apiculture, vermiculture, and aquaculture for enhanced productivity and sustainability.

SYLLABUS

UNIT I: SERICULTURE

Introduction to Sericulture - History and development of sericulture in India - Economic and cultural significance of the silk industry - Biology of Silkworms - Mulberry and non-mulberry types - Mulberry cultivation and management - Common diseases and control measures.

UNIT II: APICULTURE

Introduction to Apiculture - Historical background and importance of beekeeping - Types and species of honeybees - Beekeeping Techniques: Hive construction - installation, and seasonal management - Hive products: Honey, beeswax, propolis, royal jelly - Beekeeping as a livelihood option.

UNIT III: VERMICULTURE

Introduction to Vermiculture - History and importance in organic farming - Vermicomposting Techniques: Preparation and management of vermibeds - Process of composting and harvesting vermicompost - Applications of Vermiculture: Role in soil fertility enhancement - Use of vermiwash in agriculture - Economic and Environmental Benefits: Potential for small-scale entrepreneurship.

UNIT IV: AQUACULTURE

Introduction to Aquaculture - History and scope of aquaculture in India - Types: Freshwater, brackish water, and marine aquaculture - Aquaculture Techniques: Pond preparation, stocking, and feeding management - Identification of diseases and treatment protocols - Integrated aquaculture practices and polyculture systems.

UNIT V: INTEGRATED FARMING SYSTEMS

Integration of sericulture, apiculture, vermiculture, and aquaculture - Benefits and challenges of integrated systems - Successful models of combined practices in India - Value-Added Products: Processing and marketing strategies for farm produce - Environmental and Economic Impacts: Boosting income for farmers through diversification - Government initiatives, training programs, and subsidies.

Textbooks

1. Singh, S. (2007). Beekeeping in the Tropics. Agrotech Publishing Academy.
2. Jhingran, V.G. (1991). Fish and Fisheries of India. Hindustan Publishing Corporation.

3. Somani, L.L. (2008). Vermicomposting and Vermiwash. Agrotech Publishing Academy.
4. Dandin, S.B., et al. (2003). Handbook of Sericulture Technologies. Central Silk Board, India.
5. Boyd, C.E. (2005). Water Quality in Ponds for Aquaculture. Alabama Agricultural Experiment Station.

Reference Books

1. Ganga, G., and Sulochana Chetty, J. (1999). *An Introduction to Sericulture*. Oxford & IBH Publishing Co. Pvt. Ltd.
2. Crane, E. (1999). *The World History of Beekeeping and Honey Hunting*. Routledge.
3. Edwards, C.A., and Arancon, N.Q. (2004). *Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management*. CRC Press.
4. Kumar, V. (2016). *Integrated Farming Systems: Concept and Practices*. CBS Publishers.
5. Soni, B.K., and Dixit, R.K. (2014). *Sustainable Integrated Farming Systems*. Agrotech Publishing Academy.

GENERIC CORE II

24ULS402: INTRODUCTORY TO BIOINFORMATICS & BIOSTATISTICS

Contact Hours/ Week:04

Credits:04

Internal Marks: 25

External Marks: 75

Course Outcome:

- CO-1 Demonstrate different nucleic acid database and tools
- CO-2 Apply online software and tools for predict protein macromolecules
- CO-3 Categorize the sequence alignment methods
- CO-4 Know the various statistical method to solve different types of problem
- CO-5 Enhance knowledge of Analysis of central tendency

SYLLABUS

Unit I

Introduction to Bioinformatics – Genome, Transcriptome and Proteome, Gene prediction rules and software. Types of Nucleotide Sequence: Genomic DNA, Complementary DNA (cDNA), Recombinant DNA (rDNA), Expressed sequence tags (ESTs), Primer DNA and Design. Nucleic acid Databases – Primary and Secondary Databases – Structure Database – NCBI, CATH, SCOP – Data base Searching – BLAST and FASTA, BLOSSUM.

Unit II

Protein sequence databases: SWISS-PROT, TrEMBL, PIRPSD.GenBank, EMBL, DDBJ Protein Database: Comparison of Protein sequences and Database searching Uniprot and protein Data Bank (PDB),BLAST and FASTA- methods for protein structure prediction- Homology modeling of proteins, visualization tools (RASMOL).

UNIT III

Multiple Sequences alignment – method of multiple sequences alignment- Evolutionary analysis, clustering methods Phylogenetic trees - Methods to generate phylogenetic tree- Tools for multiple sequences alignment and phylogenetic analysis(MEGA4 or 6) - Drug Discovery, Steps in Drug design - Chemical libraries – Role of molecular docking in drug design, ADME properties.

UNIT IV

Statistics – Definition – Statistical methods- Basic principles – Variables – Measurements, functions, limitation and uses of statistics. Collection of Data: Primary and Secondary – Types and methods of data collection, Procedure, Merits and Demerits. Classification and tabulation of data – Diagrams and graphs.

UNIT V

Measures of Central tendency – Mean, Median, Mode, Geometric Mean – Merits and Demerits – Dispersion and measure of dispersion – Range, Standard deviation, quartile deviation – Merits and Demerits – Co-efficient of variations, ANOVA- One and Two way

Text Books:

1. Bioinformatics: Methods and Applications, S. C. Rastogi, Namita Mendiratta, 2013, PHI Learning Pvt Ltd, (Unit I, Unit III).
2. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Andreas D. Baxevanis, B. F. Francis Ouellette, 2005 (3rd Edition), Wiley-Interscience (Unit II)
3. Basics of Biostatistics, A. P. Kulkarni, 2019, CBS Publishers & Distributors Pvt. Ltd., India (Unit IV, Unit V)

Reference Books:

1. Fundamentals of Bioinformatics, D. E. Krane and M. L. Raymer, 2003, Pearson Education
2. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Andreas
3. D. Baxevanis, B. F. Francis Ouellette, 2005 (3rd Edition), Wiley-Interscience
4. Essential Bioinformatics, Jin Xiong, 2006, Cambridge University Press

DISCIPLINE CORE II
24UBO502: PLANT PATHOLOGY AND PLANT DISEASE
MANAGEMENT

Contact Hours/ Week: 04

Credits:04

Internal Marks: 25

External Marks: 75

Course Outcome:

- CO-1 Understand the biotic and abiotic causes of plant diseases and their agricultural significance
- CO-2 Apply knowledge of pathogen dispersal mechanisms and environmental factors to predict disease development
- CO-3 Apply integrated disease management strategies in different agricultural system
- CO-4 Analyze the effectiveness of different chemical control methods and their impact on plant health and the environment
- CO-5 Investigate safety protocols and techniques for chemical application to ensure environmental and human safety

SYLLABUS

UNIT-I: Introduction to Plant Pathology

History, progress and growth of plant pathology, Importance, definitions and concepts of plant diseases, biotic and abiotic causes of plant diseases, scope and applications of plant pathology.

UNIT-II: Pathogen Growth and Disease Development

Growth, reproduction, survival and dispersal of important plant and major pathogens, role of environment and host nutrition on disease development, General symptoms of plant diseases, Geographical distribution of diseases.

UNIT III: Principles and Methods of Plant Disease Management

Principles of plant disease management by cultural, physical, chemical and biological, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

UNIT IV: Chemical Control and Pathogen Management

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides.

UNIT V: Application and Safety of Chemicals, Biopesticides & Fungicides in Plant Protection

Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health -vis- environmental hazards, residual effects and safety measures. Application of biobacteriocides, biofungicides and biopesticides in promoting sustainable agriculture.

Text Book

1. Agrios, G. N. (2005). *Plant Pathology* (5th Edition). Elsevier Academic Press. (UNIT- I to V)

Reference Books

1. Mehrotra, R. S., & Aggarwal, A. (2013). *Plant Pathology* (2nd Edition). Tata McGraw Hill.
2. Nene, Y. L., & Thapliyal, P. N. (1993). *Fungicides in Plant Disease Control* (3rd Edition). Oxford & IBH Publishing.

DISCIPLINE CORE LABORATORY II

24UBO552: PLANT PATHOLOGY AND PLANT DISEASE MANAGEMENT LAB

Contact Hours/ Week:04

Credits:02

Internal Marks : 40

External Marks :60

Course Outcome:

- CO1 Identify biotic and abiotic causes of plant diseases and their agricultural significance
- CO2 Apply knowledge of pathogen biology and environmental factors to predict disease development
- CO3 Evaluate integrated disease management strategies for different agricultural systems.
- CO4 Analyze the impact of chemical and biological control methods on plant health and the environment
- CO5 Implement safety protocols and explore eco-friendly disease control alternatives

SYLLABUS

1. Methods to prove Koch's postulates with biotroph and necrotroph pathogens.
2. Pure culture techniques, use of selective media to isolate pathogens.
3. Preservation of plant pathogens and disease specimens.
4. Inoculation and isolation of pathogens.
5. Preparation of mount, preservation of fungi, Demonstration of appresoria and houstoriain plant pathogenic fungi.
6. Methods of in vitro evaluation of chemicals, antibiotics, bio agents against plant pathogens.
7. Field evaluation of chemicals, antibiotics, bio agents against plant pathogens.
8. Methods of application of chemicals and bio control agents.
9. ED and MIC values, study of structural details of sprayers and dusters.
10. Field study of economically important products obtained from fungi: Fungal biofertilizers, biopesticides, biofungicide.
11. Experiment on Technical Tools used in Farm.
12. Usage of haemocytometer, micrometer, centrifuge, pH meter, camera lucida

DBT STAR Programme Additional Practicals

1. Comparative estimation of chlorophyll, carbohydrate and Protein in infected and Non infected plant samples
2. Rate of photosynthesis & Respiration during pathogenesis
3. Isolation and Identification of plant pathogens from various samples
4. Purification of fungal strains (Demonstration)
5. Stains and staining techniques - detection and identification of plant pathogens.
6. Preparation of Herbarium specimens for infected plants.

Text Book

1. Ravichandra, N.G., (2014), Laboratory Manual of Plant Pathology, Scientific Publishers

GENERIC CLUSTER CORE III

24ULS403: DEVELOPMENTAL BIOLOGY AND GENETICS

Contact Hours/ Week : 04

Credits : 04

Internal Marks : 25

External Marks :75

Course Outcome:

CO-1 Understand the Key Developmental Stages such as fertilization, cleavage, gastrulation, and organogenesis across various model organisms.

CO-2 Explain the Molecular Mechanisms involved in cell differentiation, gene expression regulation, and morphogen gradients during development.

CO-3 Interpret Experimental Techniques used in developmental biology, including fate mapping, gene knockout, and live imaging.

CO-4 Analyze the Role of Signaling Pathways (e.g., Wnt, Notch, Hedgehog) in controlling developmental processes.

CO-5 Evaluate the Developmental Disorders and assess how errors in development can lead to congenital abnormalities and disease.

SYLLABUS

UNIT – I

Introduction to Developmental Biology & Model Organisms. Potency, commitment, specification, induction, competence, determination & differentiation; morphogenetic gradients; cell fate & cell lineages; genomic Equivalence and cytoplasmic determinants; imprinting. Cell-to-Cell Communication: Mechanisms of morphogenesis, Stem Cells: their potential and their niches.

UNIT – II

Gametogenesis and fertilization in animals, ultra structure of sperm and ovum, egg types, egg membrane. Fertilization, cleavage, Morula, Implantation, blastulation, gastrulation, formation of germ layers, axis formation - anterior and posterior. Sex determination - chromosomes and environment. Establishment of symmetry in plants, Seed formation and germination.

UNIT – III

Cleavage patterns and types. Axis Formation - Anterior-posterior axis formation, Dorsal-ventral and right-left axis formation, Control of blastomere identity in *C. elegans*. Organogenesis – vulva formation in *C. elegans*; eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; sex determination.

UNIT – IV

Life cycle of an angiosperm plant, Plant growth and development, Embryonic and post-embryonic development, Characteristics of plant development. Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*.

UNIT – V

Mendel's experiments; Law of segregation, monohybrid cross, reciprocal cross, back cross, test cross; ABO blood groups in human; Rh Blood group incompatibility; Human chromosomes and chromosomal Inheritance Pattern-Human Chromosomes, study of Normal Human Karyotype and abnormal karyotypes. Pattern of inheritance: Autosomal dominant –Adult polycystic kidney disease. Autosomal recessive – Sickle cell anaemia, X-linked dominant – Fragile X syndrome, X linked recessive – Duchennemus

Text Books:

1. Scott F. Gilbert, 2023, *Developmental Biology* (12th Edition), Sinauer Associates, (Unit-I to IV)
2. Hartl, D. L., Ruvolo, M., 2021, *Genetics: Analysis of Genes and Genomes* (9th Edition) (Unit-V)

Reference Books:

1. Carlson, B.M., (2020), *Human Embryology and Developmental Biology* (5th Edition), Elsevier, Philadelphia, PA.
2. Lewis, R., (2022), *Developmental Genetics* (1st Edition), Oxford University Press, Oxford, UK.

GENERIC CORE LABORATORY II

24ULS452: DEVELOPMENTAL BIOLOGY AND GENETICS LAB

Contact Hours/ Week : 04

Credits : 02

Internal Marks : 40

External Marks : 60

Course Outcome:

- CO1 Demonstrate the preparation and identification of polytene chromosomes
- CO2 Observe and identify frog embryonic stages (blastula, gastrula, cleavage)
- CO3 Examine different developmental stages of chick embryos through incubation periods
- CO4 Solve genetics problems involving Mendelian inheritance, linkage, and sex-linked traits
- CO5 Identify histological features of endocrine glands and gonads in transverse section

SYLLABUS

1. Giant Chromosome (Demonstration of polytene chromosome preparation).
2. Blastula of Frog.
3. Gastrula of Frog.
4. Study of different stages of cleavage (2-cell, 4-cell, 8-cell, 16-cell stages); morula, blastula.
5. Study of chick embryos at 18 hours, 24 hours, 33 hours, and 48 hours of incubation.
6. Problems on Genetics: Mendelian inheritance, linkage and crossing over, sex-linked inheritance.
7. T.S. of pituitary, thyroid, adrenal, ovary, and testis.
8. Kymograph (Demonstration of muscle twitch with PowerPoint).

DBT STAR Programme Additional Practicals

1. Observation of Mitotic Stages in Onion Root Tip (Squash Preparation)
2. Study of Meiosis in Grasshopper Testes/ Flower Buds
3. Preparation of Karyotype from Human Chromosome Images
4. Blood Grouping and Rh Typing (Demonstration or Chart-based)

Textbooks:

1. Lynn, A., & Gerhart, J., (2021), *Developmental Biology: A Practical Approach* (2nd Edition). Garland Science, New York.
2. Slack, J., (2020), *Essential Developmental Biology* (4th Edition). Wiley-Blackwell, Hoboken, NJ.

Discipline Centric Core - III

24UBO503 : Bryophytes, Pteridophytes, Gymnosperms and Paleobotany

Contact Hours/ Week: 04

Credits:04

Internal Marks: 25

External Marks : 75

Course Outcome:

- CO1 To understand the characters, classification and life cycle of Bryophytes and their evolutionary importance.
- CO2 To know the classification, evolutionary trends and importance of Pteridophytes.
- CO3 To compare the structure and reproduction of representative Pteridophytes.
- CO4 To understand the morphology, anatomy and reproduction of Gymnosperms with their economic importance.
- CO5 To outline fossilization, types of fossils and the significance of Paleobotany.

SYLLABUS

Unit I: Bryophytes

Bryophytes introduction - general characters and classification by Smith system (1955) . Structure, reproduction, and life cycle of representative genera: *Marchantia*, *Anthoceros*, *Polytrichum* Evolution of sporophyte in bryophytes Ecological and economic importance

Unit II: Pteridophytes

Introduction of Pteridophytes , General characteristics , Classification [Sporne system 1966]). Evolution of stelar systems heterospory and seed habit Economic and ecological importance of Pteridophytes

Unit III: Pteridophytes

Salient features of major classes systematic position Structure, reproduction and life cycle of *Lycopodium*, *Selaginella*, *Adiantum*, *Azolla* and *Marsilea* . Evolutionary trends among Pteridophytes .

Unit IV: Gymnosperms

Introduction of gymnosperms , General charactersm classification (Sporne's system - 1965) . Morphology, anatomy, reproduction and life cycle of *Cycas*, *Pinus*, and *Gnetum* Economic importance of gymnosperms and Evolutionary significance of Gnetum

Unit V: Paleobotany

Introduction of Paleobotany ,Geological Time scale - Correlation of geological time scale with plant evolution . Process of fossilization, types of fossilization . Brief study of the following fossil plants: *Rhynia*, *Lepidodendron* and *Calamites*. Indian fossil:*Glossopteris* sp . Importance of Paleobotany and contribution by Birbal Sahni .

Text Books

1. Parihar, NS (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.(Unit I,II,III)
2. Sharma, OP (2013). Bryophytes. McGraw Hill education (India) Pvt. Ltd. New Delhi.(Unit I)
3. Shukla.A.C and Misra.S.P 1982 Essentials of Palaeobotany, Vikas publishing house Pvt Ltd., Delhi. Vasishta BR, Sinha AK & Anilkumar. (2005). Botany for degree students: Pteridophytes. S Chand, New Delhi.(Unit –IV).
4. Vasishta PC, Sinha AK & Anilkumar. (2005). Botany for degree students: Gymnosperms. S Chand and Company Ltd., New Delhi.(Unit –IV)

References Books :

1. Cavers, F (1971).The interrelationship of Bryophyta. Dawsons of Pall Mall, London
2. Arnolds, C.A.(1947). An Introduction to Paleobaotany, McGraw Hill Book Co., New York.

Discipline Centric Core Theory- IV
24UBO504: Plant Anatomy & Embryology

Contact Hours/ Week: 04

Credits:04

Internal Marks: 25

External Marks:75

Course Outcome:

- CO1 To understand the types, structure and functions of plant tissues and meristem organization.
- CO2 To describe complex tissues, epidermal structures and primary anatomy of dicot and monocot organs.
- CO3 To explain normal and anomalous secondary growth in dicot and monocot stems and roots.
- CO4 To illustrate microsporogenesis, megasporogenesis and development of male and female gametophytes.
- CO5 To summarize double fertilization, endosperm and embryo development and seed structure.

SYLLABUS

UNIT – I:

Introduction: Scope and importance , type of cells and tissue , Classification of plant tissue , Meristems: Classification, distribution , structure and function . Shoot and Root apex organization and theories: Histogen, Tunica – Corpus and quiescent center . Simple permanent tissues – parenchyma, collenchyma and sclerenchyma structure, composition and function .

UNIT – II:

Complex permanent tissue: xylem, phloem structure , composition and function . Epidermal tissues : Stomatal types : (Anomocytic, Anisocytic, Paracytic, Diacytic and Gramineae). Ground tissues and vascular tissues- types . Trichomes- Types . Primary structure of normal dicot and monocot stem, leaf and root .

UNIT – III:

Normal secondary growth of dicot stem and roots - cambium – annual rings , heart wood and sap wood – periderm formation – lenticels – wound healing . Anomalous secondary thickening in stems of dicots (*Achyranthes* and *Boerhaavia*) and secondary growth in monocot stems (*Dracaena*).

UNIT – IV:

Introduction to Embryology Microsporogenesis : structure and development of the anther, structure of pollen , and development of the male gametophyte . Megasporogenesis : structure of the ovule , development of the embryo sac - monosporic, bisporic, and tetrasporic types , and structure of the mature embryo sac .

UNIT – V:

Double fertilization and triple fusion, Apomixis , Development of Endosperm: Nuclear, Cellular, Helobial and Ruminant . Structure of the dicot and monocot embryo s Polyembryony . Seed coat and seed structure for-monocot and dicot.

Text Books:

1. Pandey B,P., (2015)(Edn.) Plant Anatomy S. Chand Publ. New Delhi.
2. Bhatnagar, SP, Dantu, PK and Bhojwani, SS. (2014).The Embryology of Angiosperms 6thEditionVikas Publishing House. Delhi.

References Books:

1. Cutter, E.G. (1978). Plant Anatomy, Experimental and Interpretation. Edward Arnold Pub.Ltd., London.
2. Esau, K.(1977). Anatomy of seed plants. Wiley Eastern Publication, New Delhi.
3. Johri, B.M (1984). Embryology of Angiosperms. Springer-Verlag.

DISCIPLINE CENTRIC CORE

24UBO505 : MORPHOLOGY, TAXONOMY & ECONOMIC BOTANY

Contact Hours/ Week: 04

Credits:04

Internal Marks: 25

External Marks : 75

Course Outcome:

CO-1 Understand the basic principles and terminology of plant taxonomy and describe the morphology of root, stem, leaf, inflorescence, and fruits.

CO-2 Compare the natural systems of classification (Bentham & Hooker, APG) and explain their merits and demerits; apply rules of botanical nomenclature (ICBN/ICN) and herbarium techniques.

CO-3 Identify, describe, and classify the families of Polypetalae and Gamopetalae based on morphological characters and recognize their economic importance.

CO-4 Examine the diagnostic characters and economic value of Monochlamydeae and Monocot families.

CO-5 Evaluate the economic importance of plants used for fibres, timber, dyes, food, medicines, oils, and ornamentals.

SYLLABUS

Unit I: Plant Taxonomy Basics:

Introduction to plant taxonomy – principles - Morphology and technical terms used in taxonomy (Root, Stem, Phyllotaxy, Leaf and Flowers and modification and types – inflorescence and its types , fruits and its types .

Unit II: Classification & Nomenclature:

Natural Systems of classification – (Bentham & Hooker) - Merits and demerits of Bentham and Hooker classification, APGA - merits and demerits. Botanical nomenclature – ICBN and ICN. Herbarium techniques: Methodology of preparation , management and role of herbarium . Important herbaria and Botanical gardens of India .

Unit III : Detailed study of the range of characters and economic importance of the families:

Polypetalae: Annonaceae, Capparidaceae, Rutaceae, Anacardiaceae, Fabaceae, Cucurbitaceae and Rosaceae. Gamopetalae: Rubiaceae, Apocynaceae, Asteraceae, Asclepiadaceae, Solanaceae, Verbenaceae and Lamiaceae.

Unit IV: Detailed study of the range of characters and economic importance of the families:

Monochlamydeae: Amaranthaceae, Euphorbiaceae. Monocots: Orchidaceae, Musaceae, Liliaceae, Arecaceae and Poaceae .

Unit V: Economic Botany:

Study of the botanical name , family and morphology of the useful parts such as fibers, timber, dye, forage, food, grains, pulses, spices, beverages, latex, gums, resins, oils and ornamental plants .

Text Books:

1. Michael G. Simpson. *Plant Systematics*. Academic Press, USA, 2019. Page 1–600.
2. James G. Harris & Melinda Woolf Harris. *Plant Identification Terminology: An Illustrated Glossary*. Spring Lake Publishing, USA, 2001. Page 1–200.
3. James D. Mauseth. *Botany: An Introduction to Plant Biology*. Jones & Bartlett Learning, USA, 2014. Page 1–700.
4. Michael G. Simpson. *Plant Systematics*. Academic Press, USA, 2019. Page 45–580.
5. Tod F. Stuessy. *Plant Taxonomy: The Systematic Evaluation of Comparative Data*. Columbia University Press, USA, 2009. Page 61–190.

Reference Books:

1. Gamble JS. Flora of the presidency of Madras. Vol. I,II& III. Bishensingh Mahendrapal singh, India, 1956.
2. Lawrence GHM. Taxonomy of Vascular plants. Oxford & IBH Publishing company (P) Ltd, New Delhi, 1982.
3. Sambamurty AVSS. Taxonomy of Angiosperms. I.K. International Pvt. Ltd., 2005.
4. Sivarajan V. Principles of plant taxonomy. Oxford and IBH, 1999.
5. Subramaniam NS. Modern Plant taxonomy. Vikas publishing house, New Delhi, 1995.

Discipline Centric Core

24UBO506: Plant Drug Technology and Pharmacognosy

Contact Hours/ Week: 04

Credits:04

Internal Marks: 25

External Marks: 25

Course Outcome:

- CO-1 Understand the basics of plant drugs and their classification.
- CO-2 Explain pharmacognosy and identify different crude drugs.
- CO-3 Understand bioassay and methods used to identify plant drugs.
- CO-4 Describe medicinal plants and their uses in treating diseases.
- CO-5 Understand simple methods used in quality control of herbal drugs.

SYLLABUS:

UNIT – I Introduction to Plant Drug Technology

Introduction to plant drug technology. Classification of drugs – morphological, chemical and pharmacological. Identification of marker compounds in herbal formulations. Bioassays in plant drug evaluation. Fingerprinting techniques for identification of plant drugs. Biosynthesis of alkaloid. Metabolic pathways of selected medicinal plants (*Ocimum sanctum* and *Rauwolfia serpentina*).

UNIT – II Herbs in Medicine

Historical perspective of herbs in traditional health care systems. Ethnobotanical and medicinal importance of *Atropa acuminata*, *Catharanthus roseus* and *Digitalis purpurea* Herbal nutraceuticals and their role in managing Diabetes, cardiovascular diseases, Cancer and gastrointestinal disorders. Marketing of Medicinal Plants

UNIT – III Herbs in Cosmetics

Herbal sources of fixed oils, waxes, gums, natural bleaching agents and antioxidants for skin and hair care. Herbs used in shampoos, natural surfactants and conditioners. Biobased hair colourants and products for hair fall control. Herbs in oral health and hygiene Herbal sources of fragrances (Lavender, Rose and Rosemary).

UNIT – IV Pharmacognosy

Definition, history and scope of pharmacognosy. Sources of crude drugs – plant, animal and mineral origin. Classification of crude drugs Organised and unorganised drugs (dried juices, gums, mucilages and oleoresins) Drug adulteration and contamination – types and detection-Marketing

UNIT – V Quality Control of Herbal Drugs

Evaluation of crude drugs – organoleptic, microscopic, physical and chemical methods. Quality control methods for herbal drugs: macroscopic and microscopic examination, chromatographic techniques (TLC, HPLC), determination of water content and spectroscopic methods).

Text Books :

1. Evans, W.C. – *Pharmacognosy*, 16th Edition, Elsevier
2. Wallis, T.E. – *Textbook of Pharmacognosy*, 5th Edition, CBS Publishers
3. Kokate, C.K., Purohit, A.P. & Gokhale, S.B. – *Pharmacognosy*, 56th Edition, Nirali Prakashan
4. Tyler, V.E., Brady, L.R. & Robbers, J.E. – *Pharmacognosy*, 9th Edition, Lea & Febiger
5. Rastogi, R.P. & Mehrotra, B.N. – *Compendium of Indian Medicinal Plants*, Latest Edition, CDRI & NISCAIR (*Plant Drug Technology focus*)

Reference Books :

1. Harborne, J.B. – *Phytochemical Methods*, 3rd Edition, Springer
2. Kokate, C.K. – *Practical Pharmacognosy*, 5th Edition, Vallabh Prakashan
3. Mukherjee, P.W. – *Quality Control of Herbal Drugs*, 2nd Edition, Business Horizons
4. Heinrich, M. et al. – *Fundamentals of Pharmacognosy and Phytotherapy*, 2nd Edition, Elsevier
5. Mukherjee, P.W. – *Plant Drug Evaluation: A Laboratory Manual*, Latest Edition, Business Horizons
6. Hill A.F Economic Botany – A Text Book of useful Plants and Plant Products – McGraw-Hill Publication

DISCIPLINE CENTRIC CORE LABORATORY –III

24UBO553: Plant Diversity, Taxonomy, Economic Botany and Pharmacognosy lab

Contact Hours/ Week: 03

Credits: 2

Internal Marks: 40

External Marks: 75

Course Outcome:

- CO-1 Understand the structure and reproduction of Bryophytes, Pteridophytes, and Gymnosperms and the importance of fossil plants.
- CO-2 Develop practical skills in plant anatomy and embryology through sectioning and slide study.
- CO-3 Study morphological variations of root, stem, leaf, inflorescence, flower, and fruit.
- CO-4 Identify and classify angiosperms using floral characters and taxonomic principles.
- CO-5 Recognize economically important plants and their uses in daily life.

SYLLABUS:

BRYOPHYTES, PTERIDOPHYTES, GYMNOSPERM AND PALEOBOTANY

1. Detailed microscopic analysis of vegetative and reproductive parts of the following Bryophytes: Marchantia and Polytrichum
2. Study of the Habit, TS of leaf and Stem, Morphology of Reproductive structures of following Pteridophytes: Selaginella and Marsilea.
3. Study of the Habit, TS of leaf and stem, Morphology of Reproductive structures of following gymnosperm genera Cycas, Pinus and Gnetum.
4. Study the following fossil members: Rhynia, Lepidodendron and Calamites, through permanent slides/photographs

ANATOMY AND EMBRYOLOGY

1. Study of primary structure and sectioning of Dicot stem, root, leaf, Monocot stem, root and leaf.
2. Anomalous secondary structures –Achyranthes and Boerhaavia studied by permanent Slide
3. Identifying Stomatal types using leaf peel method and determination of stomatal index.
4. T.S of Anther
5. Structure of Male gametophyte and Female gametophyte studied by Permanent Slides/photographs

MORPHOLOGY:

1. Study of Morphological Characters Leaf, Stipule, Stem and Root, Inflorescence, flower and Fruits.

TAXONOMY:

1. A detailed study of locally available plant groups with reference to their habitats, corresponding to the families included in the syllabus.

ECONOMIC BOTANY:

Study of economically important plants — Identification of botanical name, family, and useful part of the following fibers, timber, dye, forage, food, grains, pulses, spices, beverages, latex, gums, resins, oils and ornamental plants.

Text Books

1. Practical Botany (Vol. I & II) – Ashok Kumar & Ashok M. Bendre, Latest Reprint (2025), Rastogi Publications
2. Eames, A.J. and MacDaniels, L.H. – *An Introduction to Plant Anatomy*. McGraw Hill Book Company.
3. Rendle, A.B. – *The Classification of Flowering Plants (Vol. I & II)*. Cambridge University Press.

Reference Books

1. Coulter, J.M. & Chamberlain, C.J. – *Morphology of Gymnosperms*. Central Book Depot, Allahabad.
2. Smith, G.M. – *Cryptogamic Botany (Vol. I & II)*. McGraw Hill Book Company, New York..
3. Radford, A.E. – *Fundamentals of Plant Systematics*. Harper & Row Publishers, New York.
4. Hill, A.F. – *Economic Botany: A Textbook of Useful Plants and Plant Products*. McGraw Hill Book Company, New York.

Technical Skill
24UBO381:Digital Herbarium

Course Overview Contact Hrs : 2
Internal Marks: 40 Marks

Credits:2
External Marks: 60 Marks

Course Outcome:

- CO1- Explain concepts and importance of herbarium and digital herbarium
- CO2 - Apply plant collection and preservation techniques
- CO3 - Develop digital herbarium records using imaging tools
- CO4 - Analyze plant data using herbarium software and databases
- CO5 - Evaluate applications of digital herbarium in research and conservation

Syllabus

Unit I: Introduction to Herbarium

Definition, history and importance of herbarium; types of herbaria such as national, regional and institutional; role in taxonomy, systematics and biodiversity conservation; concept, need and advantages of digital herbarium over traditional methods.

Unit II: Plant Collection and Preservation

Methods of plant collection; field techniques and ethical considerations; recording of field data including locality, habitat and GPS details; techniques of pressing, drying and preservation; mounting and labeling of herbarium specimens.

Unit III: Digitization Techniques

Principles of plant photography; use of scanners and digital cameras; image processing and editing; preparation of metadata including scientific name, family and collection details; standards and protocols for herbarium digitization.

Unit IV: Herbarium Software and Database Management

Introduction to herbarium software tools; database creation and management; data entry, storage and retrieval; overview of online herbarium portals and virtual herbaria; use of mobile applications for plant identification.

Unit V: Applications of Digital Herbarium

Applications in biodiversity conservation, taxonomy and ecological research; role in education and scientific documentation; use in climate change studies and environmental monitoring; integration with global plant databases and case studies.

Text Books:

1. Jain, S.K. & Rao, R.R. (1977). A Handbook of Field and Herbarium Methods. Today & Tomorrow's Printers and Publishers, New Delhi.
2. Bridson, D. & Forman, L. (1998). The Herbarium Handbook (3rd ed.). Royal Botanic Gardens, Kew, UK.
3. Singh, G. (2019). Plant Systematics: Theory and Practice (4th ed.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Simpson, M.G. (2010). Plant Systematics (2nd ed.). Academic Press, Elsevier, USA.

Reference Books

1. Lawrence, G.H.M. (1951). Taxonomy of Vascular Plants. Macmillan Company, New York.
2. Radford, A.E., Dickison, W.C., Massey, J.R. & Bell, C.R. (1974). Vascular Plant Systematics. Harper & Row Publishers, New York.
3. Woodland, D.W. (2009). Contemporary Plant Systematics (4th ed.). Andrews University Press, USA.
4. Forman, L. & Bridson, D. (2004). The Herbarium Handbook (Revised ed.). Royal Botanic Gardens, Kew, UK